MATERIALS SCIENCE

Read the General Rules in the manuals and on www.soinc.org as they apply to every event.

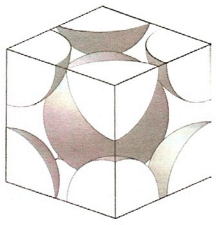
1. **DESCRIPTION**: Teams will answer a series of questions or complete tasks involving the science processes of chemistry focused in the areas of Materials Science.

   A TEAM OF UP TO: 2 **EYE PROTECTION**: #4 **APPROXIMATE TIME:** 50 minutes

2. **EVENT PARAMETERS**:
   a. **Teams** may bring: a handheld nonprogrammable calculator, a writing utensil and one 3-ring binder (any size) containing pages of information in any form from any source that must be 3-hole punched and inserted into the rings (sheet protectors are allowed).
   b. **Event Supervisors** will provide: any materials needed for **lab stations**.
   c. **Safety Requirements**: Students must wear the following or they will not be allowed to participate: closed-toed shoes, ANSI Z87 indirect vent chemical splash goggles (see http://soinc.org), pants or skirts that cover the legs to the ankles, and additionally a long sleeved lab coat that reaches the wrists and the knees or a long sleeved shirt that reaches the wrists with a chemical apron that reaches the knees. Chemical gloves are optional, **but recommended**. Students who unsafely remove their safety clothing/goggles or are observed handling any of the material or equipment in a hazardous/unsafe manner (e.g., tasting or touching chemicals or flushing solids down a drain and not rinsing them into a designated waste container provided by the supervisor) will be **penalized** or disqualified from the event.

3. **THE COMPETITION**:
   a. The competition will focus on students evaluating the properties of materials and answering questions related to the materials' chemistry: 1) Evaluating the mechanical performance of materials; 2) Evaluating the intermolecular forces of materials.
   b. The event will consist of an activity or activities with supporting questions. The questions will be scaffolded such that students are guided from the observed bulk properties to principal chemical properties; "macro" to "micro" scale. Supervisors are encouraged to use computers or calculators with sensors/probes wherever possible. Students may be asked to collect data using probeware that has been set-up and demonstrated by the Supervisor. The supervisor may provide students with data sets collected by such sensors and probes following demonstration of the data collection. Digital microscopes and cameras connected to computers are encouraged.
   c. Cleanup should occur after all materials have been returned or a penalty may be given.
   d. Students will be expected to interpret data by preparing data tables and/or construction of graphs of the data. Completeness, accuracy and quality of data tables and graphs will be taken into account.
   e. All measurements must be recorded with correct significant figures and units. All calculations must also include correct significant figures and units.

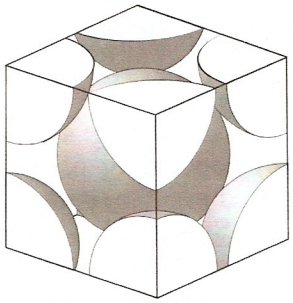
4. **LAB STATIONS**: Material Performance & Atomic/Molecular Structure Topics are limited to:
   a. **General properties and characteristics of material classes** (metals, ceramics, polymers, composites)
      i. Physical characteristics (Density, strength, thermal properties, etc.)
      ii. Manufacturing techniques and natural occurrences
      iii. Chemical Composition (elements, bonds, etc.)



   b. **Material characterization techniques**
      i. Visual (Optical and electron microscopy)
      ii. Physical tests
         1) Stiffness of material - Young's Modulus
         2) Breaking strength of a material - Yield Strength
         3) Surface Area/Volume ratio
         4) Permanent deformation of material under constant load - Creep Rate
         5) Resistance to flow - Viscosity
         6) Resistance to fracture - Fracture toughness (State and National tournaments)
         7) Resistance to repetitive strain - Fatigue Limit (State and National tournaments)
         8) Stiffness under shear load - Shear Modulus (State and National tournaments)
         9) Transverse, inherent strain - Poisson's Ratio (State and National tournaments)

iii. Material selection for specific applications - Choosing the best material for an application based off of a list of materials and their properties

c. **Intermolecular Forces and Surface Chemistry**
   i. Chemical tests
      1) Surface Chemistry, surface tension, contact angle
      2) Thickness of a molecule
   ii. Crystal Structures
      3) Ionic, Covalent, Crystalline, Semi-Crystalline, Amorphous
      4) Common atomic packing (FCC, BCC, HCP, Simple Cubic)
      5) Atomic packing factor (Geometry only)



5. **SAMPLE QUESTIONS**:

   a. **Material Performance Relationships**:
      i. Using an apparatus provided by the event supervisor: generate a stress vs. strain curve, and calculate Young's modulus, identify the yield strength and offset yield strength.
      ii. For a ceramic material, what types of bonds are generally formed, and how does this contribute to properties such as density, hardness, and brittleness.
      iii. Students may be asked to perform mechanical tests to identify an ideal material for a given application.

   b. **Intermolecular Forces and Surface Chemistry:**
      i. Based on droplet characteristics, characterize the hydrophobicity or hydrophilicity of the provided surfaces. For example, students may be asked to identify unknown surfaces or rank the hydrophobicity of the provided surfaces.
      ii. Using the Wilhelmy plate apparatus and the provided equation, determine the surface tension of a liquid. Evaluate changes in surface tension with the application of surfactants or other liquids.
      iii. Students may be provided images to measure contact angles, evaluate boiling point of liquids, perform polymer melt tests for crosslinking, and will answer question related to these measurements.
      iv. Students may be expected to answer questions or complete labs and activities such as: Using materials supplied by the event supervisor to model packing for cubic or hexagonal crystal structures. Answer questions related to unit cell characteristics and properties such as formula, density, and dimensions, packing factor, etc.
      v. Students may be asked to create a droplet/surface to meet the contact angle designated by the Event Supervisor. Students may be asked to perform tests at surfaces (liquid or solid) and identify the ideal material for a given application.

6. **SCORING**: **Intermolecular Forces section (lab and written exam) 50% and Material Performance section (lab and written exam) 50%.** All ties will be broken by pre-selected questions chosen by the supervisor. These questions may or may not be identified to the students. Any graphs that are generated will be evaluated on these basic parameters (partial credit may be given): Points should be given for a correct title, and X and Y-axis labels including appropriate units and axis increments. Additionally, students may be required to create a best-fit line for the data points, identify specific points on the graph such as yield strength, and/or others designated by the event supervisor that relate directly to the property being measured. Any calculations relating to generated graphs should have work clearly shown on a provided page with proper units.

   Recommended Resources: All reference and training resources including the **Chem/Phy Science CD (CPCD)** are available on the Official Science Olympiad Store or Website at http://www.soinc.org